REMARKS

Pages 29 to 31 of the specification have been amended, for increased consistency with the remainder of the specification and with the drawings.

A Supplemental Information Disclosure Statement is filed concurrently herewith, providing an English translation of previously cited document JP 7-171142.

Favorable consideration and early passage to issue of the present application are respectfully requested.

Applicants' undersigned attorney may be reached in our Costa Mesa, California office at (714) 540-8700. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,

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[Title of the Invention] RADIATION DIAGNOSIS APPARATUS

[Abstract]

[Objective]

To provide a radiation diagnosis apparatus that eliminates for an image the adverse affects produced by frontal lighting-type a plane detector or a photo pickup, and that can obtain an optimum exposure without performing a test exposure.

[Means for Resolution]

A radiation diagnosis apparatus which includes radiation exposure means 10, an image intensifier 20 for converting a radiation image into an optical image, and a TV camera 40 for picking up an optical image, comprises:

a nondestructively-readable solid-state image pickup device built into the TV camera;

means 73 for adding a pixel value of an image by a nondestructive reading of the solid-state image pickup device;

means 74 for halting the radiation exposure when the pixel value obtained by the means 73 exceeds a predetermined value; and

means 50 and 60 for, after the exposure has been halted, reading out image information accumulated in the solid-state image pickup device.

[Claims]

[Claim 1]

A radiation diagnosis apparatus including radiation exposure means for exposing to radiation, an image intensifier located opposite to said radiation exposure means with respect to an object, for converting a radiation image of said object obtained by being exposed to said radiation into an optical image, and a TV camera for photographing the optical image, characterized by

a nondestructively-readable solid-state image pickup device, built into the TV camera;

means for adding a pixel value of an image by the nondestructive reading of said solid-state image pickup device;

means for halting said radiation exposure when a pixel value obtained by said addition means exceeds a predetermined value; and

means for, when the exposure is halted, reading out image information from said solid-state image pickup device.

[Claim 2]

A radiation diagnosis apparatus according to claim 1, further comprising:

means for designating a nondestructive reading area of said solid-image pickup device.

[Claim 3]

A radiation diagnosis apparatus according to claim 1 or 2, characterized in that the pixel value obtained by the nondestructive reading is multiplied by a predetermined weight coefficient.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a radiation diagnosis apparatus that employs an image intensifier (hereinafter referred to as "I.I.") to convert, into an optical image, a radiation image obtained by exposing an object to radiation, and that displays this optical image on a monitor through a TV camera, so that the object can be diagnosed. The present invention especially relates to a radiation diagnosis apparatus that has a function for appropriately controlling the amount of radiation exposure.

[0002]

[Prior Art]

Conventionally, in a spot bed apparatus which is an X-ray diagnosis apparatus that is one type of radiation diagnosis apparatus, and develops, directly on film, X-rays that have passed through an examinee, a frontal lighting-type plane detector is positioned as an exposure gauge in front of the film, and monitors the amount of X-rays that have entered the detector, so that an optimum exposure amount can be provided. That is, when the total amount of radiation entering the detector exceeds a specific threshold value, an X-ray tube is controlled to halt the exposure of X-rays.

[0003]

On the other hand, in a digital X-ray apparatus which is another type of X-ray diagnosis apparatus that

employs an I.I. to convert into an optical image X-rays that have passed through an examinee, and that employs a TV camera to photograph the optical image, a photo pickup and a photoelectron multiplying tube (PMT) are positioned between the I.I. and the TV camera to constantly monitor the I.I. output, so that an optimum amount of light enters the TV camera. For this apparatus, test exposure is performed several times in advance, and when the PMT output reaches a set value representing the optimum exposure amount, the exposure of X-rays is halted to determine the X-ray emission condition for photography, and the photography is thereafter initiated.

[0004]

[Problems to be solved by the Invention]

The X-ray diagnosis apparatus that employs the above described conventional exposure amount measurement method has the following problems. Specifically, in the spot bed apparatus that employs a frontal lighting-type, plane detector, since this detector is located in the X-ray irradiation area, there are adverse effects, such as the deterioration of image quality. Whereas, since the digital X-ray apparatus using the photo pickup requires test exposure, there is a problem in the increase in the amount of radiation to which the examinee is exposed. Further, as another problem, since the photo pickup is located along the I.I. output light path, an eclipse, etc., occurs, and thereby the image quality is deteriorated. As an additional problem,

since a special circuit or mechanism is required, the cost is increased.

[0005]

It is, therefore, one objective of the present invention to provide a radiation diagnosis apparatus that can eliminate adverse effects, which affect image quality, due to frontal lighting-type, a plane detector or a photo pickup, and that can obtain an optimum exposure without performing test exposure.

[0006]

[Means for Solving the Problems]

To resolve the above shortcomings and to achieve the objective, according to the present invention, a radiation diagnosis apparatus which includes radiation exposure means for exposing to radiation, an image intensifier located opposite to the radiation exposure means with respect to an object, for converting a radiation image of the object obtained by being exposed the radiation into an optical image, and a TV camera for photographing the optical image, comprises;

a nondestructively-readable solid-state image pickup device built into the TV camera;

means for adding a pixel value of an image by the nondestructive reading of the solid-state image pickup device;

means for halting the radiation exposure when a pixel value obtained by the addition means exceeds a predetermined value; and

means for, when the exposure is halted, reading out image information from the solid-state image pickup device.

[0007]

Further, the radiation diagnosis apparatus preferably comprises means for designating a nondestructive reading area of the solid-image pickup device. Furthermore, it is preferable that the pixel value obtained by the nondestructive reading be multiplied by a predetermined weight coefficient.

[0008]

[Operation]

According to the above-described feature of the present invention, the following operations are obtained. Specifically, the nondestructively-readable solid-state image pickup device is employed as an input device for the radiation TV camera. In a solid-state image pickup device which is not capable of nondestructive read-out, when it is in a light receiving state, charges corresponding to the amount of incident light are stored in the individual pixels. However, when these charges are extracted as image information from outside the device, no more charges will remain in the device. Thus, once image information is read out, only the charges that are received thereafter can be read. On the other hand, in a nondestructively-readable solid-state image pickup device, the charges accumulated in the device are not destroyed, even when the charges are extracted as image information from outside the device.

Therefore, an output can be obtained that is in proportion to the amount of the charges that have been accumulated in the pixels up to halfway of the accumulation, and the accumulation operation can be continued. Therefore, when an output proportional to the amount of charges exceeds a reference value, the radiation exposure need only be halted, and at this time, the image information need only be read out from the entire area of the device and output as normal image signals. Then, the appropriate exposure amount can be obtained. Further, when the nondestructive reading area of the device is designated, the radiation can be halted at a time when, through the exposure, an appropriate brightness is obtained in the designated area.

[0009]

[Embodiment]

Fig. 1 is a block diagram showing the configuration of an X-ray diagnosis apparatus according to one embodiment of the present invention. In Fig. 1, reference numeral 10 denotes an X-ray tube; 20, an I.I.; 30, an optical system; 40, a TV camera; 50, a TV camera drive circuit; 60, a signal processor; and 70, an automatic luminance adjusting circuit.

[0010]

The X-ray exposure condition of the X-ray tube 10 is controlled by an X-ray controller 11. The output terminal of a comparator 74, which will be described later, is connected to the X-ray controller 11. A CMD (Charge Modulation Device), which is a nondestructively-readable and random-accessable

solid-state image pickup device, is employed as the input device of the TV camera 40.

[0011]

The TV camera drive circuit 50 includes a driver 51 for driving the TV camera 40, and an address generator 52 for designating an area from which image information of the TV camera are to be read. It should be noted that the address generator 52 includes a plurality of address designation information to be used to read pixels from a plurality of areas ROI (Regions Of Interest) corresponding to lighting fields that have been designated in advance. The address generator 52 also includes address designation information to be used to perform the all-pixels reading operation in the normal photographic mode.

[0012]

The signal processing unit 60 includes: an amplifier 61 for amplifying the output of the TV camera; an A/D converter 62, for performing an A/D conversion of an amplified signal; a processing unit 63 for performing the signal processing, to be described later; and a D/A converter 64 for performing a D/A conversion for a processed signal. The output terminal of the comparator 74, which will be described later, is connected to the processing unit 63, and a processor which is not shown is connected to the output terminal of the processing unit 63.

[0013]

The automatic luminance adjusting circuit 70

includes: a weight memory 71 used for storing a plurality of the areas ROI of the lighting fields designated by an operator, and weighting coefficients that correspond to the address designation information to be; a first operating unit 72 for multiplying the output of the A/D converter 62 by the data stored in the weight memory 71; a second operating unit 73 for performing the addition for the output of the first operating unit 72; and the comparator 74 for comparing the output of the second operating unit 73 with a reference value that is set in advance as an appropriate exposure amount, and for outputting a signal to the X-ray controller 11 when the reference value is exceeded.

[0014]

Predetermined information has been entered in advance into for the address generator 52 and the weight memory 71 by the operator through an operation panel (not shown). The thus arranged X-ray diagnosis apparatus of this embodiment is operated in the following manner. Specifically, when preparing for the photographic process, an operator employs the operation panel to select the area ROI of the lighting field from samples which have shapes as shown in Figs. 3(a) and 3(b), so that the portion to be diagnosed is included in the selected area ROI. When the preparation has been completed and the operator enters a photographic instruction, an examinee P positioned between the X-ray tube 10 and the I.I. 20 is exposed to an X ray from the X-ray tube 10. At the same time, the address generator 52 automatically

starts the photo timer mode, generates an address to designate the area ROI of the lighting field, which has been selected in advance, and through the driver 51, drives the image pickup device CMD of the TV camera 40.

[0015]

In the photo timer mode, an image signal output from the TV camera 40 is passed through the amplifier 61 and the A/D 62 to the processing unit 63 and the first operating unit 72 of the automatic luminance adjusting circuit 70. At this time, the processing unit 63 does not perform any processing. And based on the area ROI of the lighting field, which has been selected in advance, an order of pixels to be read are output by the TV camera 40 in a predetermined order. For this predetermined order (the timing), the weight value, which correspond to the area ROI of the lighting field designated in advance by the operator and the address designation information, is read from the weight memory 71, and a weight coefficient is multiplied by a corresponding pixel by the first operating unit 71. It should be noted that a large value is designated for the weight coefficient, so that the exposure for a portion that is especially required for the diagnosis is reflected onto a sample value, which will be described later among the selected area ROI of the lighting field.

[0016]

On the other hand, an image signal obtained by the first operating unit 72 is added by the second operating unit

73 and is employed as a sample value of the image data in the area ROI of the lighting field of the TV camera 40. A sample value of the image data is transmitted to the comparator 74 as a sample value at t_I. The comparator 74 compares the input sample value with a predetermined reference value. The address generator 52 repeats to generate an address signal at a predetermined period until the photo timer mode is terminated. Thus, during time T_2 Ta Tn, charges accumulated in the CMD of the TV camera 40 are monitored sequentially as sample values. At time T_{II}, whereat the sample value exceeds the reference value, the comparator 74 outputs an X-ray halt signal to the X-ray controller 11. When the sample value does not exceed the reference value, the comparator 74 waits until the next sample value is input. At this time, since the cycle for inputting the sample value is proportional to the number of pixels in the area ROI, the timing for the inputting of a new sample value is earlier, as the area ROI is narrow, and an image corresponding to more adequate exposure amount can be obtained.

[0017]

When the X-ray emission is halted in this manner, the address generator 52 terminates the photo timer mode and starts the photographic mode. In the photographic mode, image information are read out. And since the CMD of the TV camera is read out nondestructively, and since information obtained since the initiation of the exposure are accumulated without any data loss, the image data across the entire area

can be read out by random access at a high speed and with no waste. The obtained image information is transmitted through the amplifier 61 and the A/D converter 62 to the processing unit 63, which then performs the image processing. The processed image information is output to the processor and the D/A converter 64. And through a D/A conversion performed by the D/A converter 64, the resultant image information is output to the monitor and an image corresponding to an adequate exposure amount is displayed.

[0018]

As is described above, since the X-ray diagnosis apparatus of this embodiment employs a nondestructively-readable CMD, the exposure amount can be measured without a detector or a photo pickup, so that the quality of an image displayed on the monitor is not adversely affected.

[0019]

In the photo monitor mode, since a sample value is measured for the exposure only in the area ROI of the lighting field that has been designated in advance, the interval for obtaining the sample value can be shortened compared with read-out of all the pixels, and thus the measurement of a more accurate exposure amount can be performed. Further, instead of adjusting an exposure amount uniformly over the entire image, the weight coefficient is multiplied for the exposure of a designated portion. As a result, an appropriate exposure amount for a portion required for the diagnosis can be determined. In addition, since

multiple types of address designation information to be are provided for the addresses, an operator can select the area ROI of the lighting field that matches the portion to be photographed. It should be noted that a nearly arbitrary size and shape can be designated for the area ROI of the lighting field that is designated by employing the above method. Thus, the operator can select an appropriate area for the diagnosis.

[0020]

The present invention is not limited to the above description. For example, the shape of the area ROI is not limited to the shape shown in Fig. 3. Furthermore, instead of selecting an area from among area samples ROI that have are prepared in advance, the operator may designate an area ROI for an arbitrary shape. In addition, the obtained image data may be provided as photographs. Thus, it is natural that a greater number of modifications of the present invention can be made without departing from the scope of the invention.

[0021]

[Advantages of the Invention]

According to the present invention, a pixel value is read out from the nondestructively-readable solid-state image pickup device, and when the pixel value exceeds a predetermined value, radiation exposure is halted, so that an appropriate exposure amount can be obtained. Further, since image data accumulated in the solid-state image pickup device

are not destructed by reading, the image data can be read after the radiation exposure is halted. Therefore, since the exposure amount can be measured without a detector or a photo pickup, the quality of an image displayed on the monitor is not adversely affected. In addition, since test exposure is not required, a radiation diagnosis apparatus can be provided which can minimize the radiation received by the examinee.

[0022]

Since the exposure amount is measured only for a predesignated lighting field during the exposure amount measurement process, a more accurate exposure amount can be obtained compared with when all the pixels are read. Furthermore, since the weight coefficient is multiplied only for the exposure of a designated portion, instead of adjusting an exposure amount uniformly over the entire image, an appropriate exposure amount can be obtained for a portion for which a diagnosis is required.

[Brief Description of the Drawings]

[Fig. 1]

A block diagram showing the configuration of an X-ray diagnosis apparatus according to one embodiment of the present invention.

[Fig. 2]

A diagram showing a sample value for the above apparatus in the photo timer mode.

[Fig. 3]

A diagram showing a sample area ROI for a lighting

field stored in the above apparatus.

[Description Of The Reference Numerals And Signs]

10: X-ray tube

11: X-ray controller

20: I.I.

30: optical system

40: TV camera

50: TV camera driver

51: driver

52: address generator

60: signal processor

61: amplifier

62: A/D converter

63: processing unit

64: D/A converter

70: automatic luminance adjusting circuit

71: weight memory

72: first operating unit

73: second operating unit

74: comparator

[Fig. 1]

11: X-ray controller

51: driver

52: address generator

71: weight memory

74: comparator

to processor

to monitor

pixel value in ROI

ROI switching

sample value

reference value

[Fig. 2]

reference value

sample value

time